Multicontrast keyhole imaging enables economy of acquisition time up to 50% in standard diagnostic MRI-knee protocols.

U. Schuetz[1], A. Bornstedt[2], and V. Rasche[2]

[1]Diagnostic and Interventional Radiology, University of Ulm, Ulm, Germany, [2]Internal Medicine II, University of Ulm, Ulm, Germany

Introduction

Standardized protocols with different contrasts are generally used in native MRI for joint diagnostics. These protocols differ only slightly. Usually T1-, T2- and PD-weighted images with and without fat suppression (fs) are used. As multi-contrast application is necessary for sufficient differential diagnosis, longer acquisition times are needed. Due to a growing demand on the use of MRI in the area of skeletal radiology, the economy of time is an important criteria of process optimization. So, the question of how to optimize or reduce the acquisition time is for a long time main topic. Based on MRI of the knee joint, it is demonstrated, how the use of a specific multi-contrast keyhole imaging technique that uses high- and low-frequency components of the k-space for different contrast weightings separately, can produce substantial time savings with respect to a native knee protocol maintaining similar subjective contrast quality of individual sequences.

Methods

Five patients with different knee joint pathologies (joint degeneration, rheumatoid arthritis, ACL-tear, meniscal tear, contusion) were included in the study (mean age 46 +/-23). The data were acquired using a full body-scanner (Achieva 3.0 T, Philips, Netherlands) with the use of an 8-channel knee coil with parallel imaging possibilities. The MRI acquisition protocol, containing coronal and sagittal TSE-sequences (T1w, PDw, T2w, PDw-fs, T2w-fs) was performed using following acquisition parameters: parallel imaging factor 2, spatial resolution in phase encoding direction (RL/AP) 0.57 mm, read direction 0.42 mm (FH). For generation of the wanted multicontrast images (MC) the central k-space ("keyhole") resp. the low frequency image components of the specific original contrasts (OC: PDw, T2w, PDw-fs, T2w-fs) were used. For filling up the peripheral k-space (high frequency image components) resp. for the sharpness of the image, the T1-weighted image (same slice) was used (OS: T1w). The smaller the central low-frequency usage of the k-space ("k-space-saving") resp. the larger the peripheral filling with OS-contrast, the better is the saving of time. Two independent, experienced skeletal radiologists, compared MC- to OC-images. For rating signal contrast and resolution/sharpness of the images, we developed an integer 7-point ordinal-scale: +3 (optimal) to –3 (nonexistent). With this rating-scale assessment of the different tissue components of the knee joint and their pathologies (e.g. bone edema, subcortical cysts, chondropathia, meniscal tear, synovitis) was done. The evaluation of maximal possible k-space-saving was carried out in 10%-intervals. As soon as only 1 point rating-difference was evaluated in any tissue component, the respective MC-image was not accepted and the highest possible k-space-saving in terms of percentage was achieved.

Results

Regarding the 7-point quality rating-scale a high inter-rater correlation was figured out (Kendall rank-correlation-coefficient: $\tau = 0.89$). Composing fat saturated MC-images (k-space centre: PDw-fs or T2w-fs), a k-space-saving up to 60% was possible without loss of quality concerning signal-contrast and sharpness in any specific tissue or pathological sign. In other words, in this cases, up to 60% of the k-space could be filled up peripheral with high-frequency T1w-image-data sustaining unchanged diagnostic quality. Regarding the non fat saturated PDw- and T2w-MC-images a k-space-saving of even 70% was possible. So, these images needed only 30% of OC-low frequency data in the middle of the k-space. Fig.1 shows the mean rating over all included 5 cases concerning signal-contrast- and sharpness-quality of the respective tissue components in MC-images using PDw-fs as OC. Depending on the amount of shared k-space data, the RMS-error is rising: before a loss of image-quality was verifiable, the RMS error could reach up to 10-15% in fat saturated and to 15-22% in non fat saturated MC-images (Fig.1). The implementation of these results on the standard native MRI-diagnosis protocol of the knee of our department, will lead to a saving of 50.0% of the net acquisition time.

Discussion

Using the presented MCKI-technique, it is possible to save at least half of net acquisition time in standard MRI-knee protocols without loss of quality in the specific PDw- and T2w-multicontrast images. We suppose successfully application of this technique in other joints and regions of the muskulosceletal system with breakeven diagnosic performance compared to monocontrast imaging, also. Escpecially in radiological units specialised on orthopaedic imaging the MCKI-technique will provide immense economical resources. Furthermore, the saved time could be spent in quality improvement procedures. Application in other fields of MRI (3D-imaging, motion-MRI) will show the advantages and limits (e.g. motion artifacts) of this promising technique.
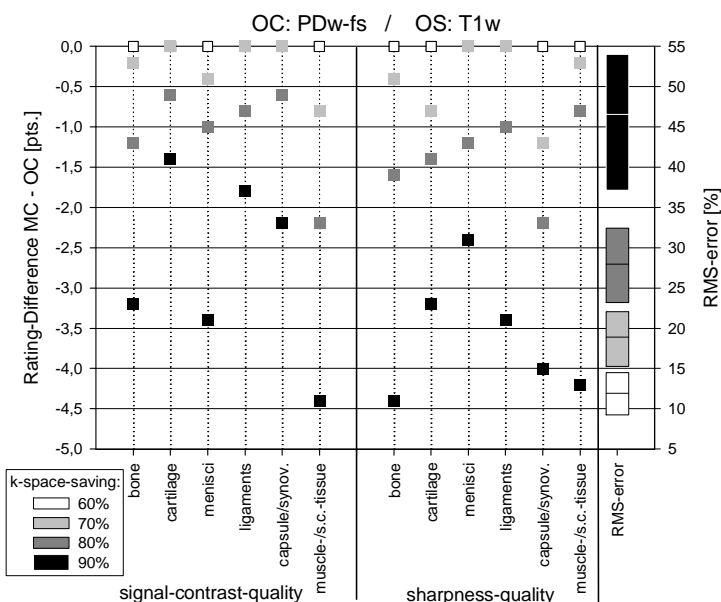

Figure 1: Tissue specific rating of image-quality depending on percentage of k-space-saving using PDw-fs-contrast for low-frequency data ("keyhole"; OC) and T1w-contrast for peripheral k-space-filling (OS).
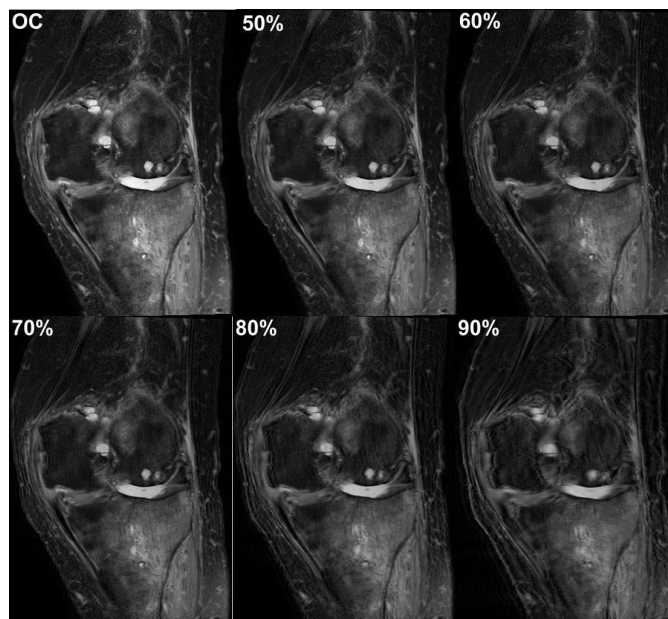

Figure 2: Mutilating rheumatoid arthritis of the knee: Resulting MC-image signal difference depending on the percentage of shared k-space data resp. k-space-saving (OC: PDw-fs, OS: T1w)